Climate Change *and Wildfire*

DESCRIPTION

Students analyze and then showcase wildfire and climate data by developing a creative project to communicate data trends to nonscientist audiences.

PHENOMENON

Is there a relationship between the number of large wildfires in the western U.S. and increased temperatures, evapotranspiration or fuel?

GRADE LEVEL
9-12

OBJECTIVES

Students will:

- Evaluate factors that contribute to large wildfire occurrence in different ecosystems.
- Analyze data to determine patterns in wildfire and climate change across different regions of the western U.S.
- Develop a creative project to communicate a data trend to a non-scientist audience and present to the class.

TIME

2.5 HOURS TOTAL OVER 3 DAYS

COMMON CORE STATE STANDARDS

English Language Arts

CCSS.ELA-LITERACY.RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

CCSS.ELA-LITERACY.RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

CCSS.ELA-LITERACY.RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

CCSS.ELA-LITERACY.RST.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data	ESS3.B: Natural Hazards	Patterns
Using Mathematics and Computational Thinking	ESS3.C: Human Impacts on Earth Systems	Cause and Effect
Constructing Explanations and Designing Solutions	ESS3.D Global Climate Change	Scale, Proportion, and Quantity
Obtaining, Evaluating, and Communicating Information		

AGRICULTURE, FOOD, AND NATURAL RESOURCES (AFNR) STANDARDS

CCTC Standard: NRS.01 Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator: NRS.01.03 Apply ecological concepts and principles to atmospheric natural resource systems.

Sample Measurements:

NRS.01.03.02a Research and summarize how climate factors influence natural resource systems.

NRS.01.03.02b Analyze the impact that climate has on natural resources and debate how this impact has changed due to human activity.

BACKGROUND

Wildfires are a natural part of many ecosystems. Many ecosystems have a unique fire regime, or pattern of how frequent, large, and severe fires are when naturally caused by lightning strikes. These fires can be catastrophic and destructive. However, when fires happen regularly, they can support healthy ecosystems by clearing away the dead plant material that may build up or by preventing a forest from becoming too crowded with small trees. Humans have altered fire regimes in many ways by introducing new ignition sources (cars, cigarettes, campfires, fireworks and power lines, to name a few), by altering fuel loads and plant communities (introducing new plant species or removing others and by introducing grazing livestock that eat small plants), and by suppressing fires through constant firefighting, leading to a build-up of flammable materials in some ecosystems. Climate change adds another layer of complexity to changing fire regimes.

Very Large Fires (VLFs) are fires that burn more than 5,000 hectares (12,355 acres). They account for a very small percentage of large wildfires but make up a majority of burned area. Under climate change modeling scenarios, VLFs are projected to increase in the majority of the western U.S. in the future. Several climatic factors influence the occurrence of these fires, including temperature, precipitation, relative humidity, and drought severity. Climate change is predicted to increase wildfire danger in two ways: 1) increased evapotranspiration and 2) increased fuel load (see "Wildfire: Past and Future" for more information). Potential evapotranspiration (PET) is defined as the amount of water transpired by a plant given an adequate amount of water. Above ground dead biomass is a characteristic that indicates fuel load in an area and is measured in grams of carbon per meter squared.

The U.S. is divided into ecoregions, or areas with similar ecosystems, at different hierarchical levels. The majority of the western U.S. can be classified as one of five ecoregions, although there are several other ecoregions or classifications that can be used (EPA). In areas that are flammability-limited (i.e., wet forests in the Pacific Northwest), fires will increase as it gets hotter and drier. In areas that are fuel-limited (i.e., deserts, non-forested ecosystems), warmer temperatures will cause existing vegetation to die. This reduces connectivity of fuels, and fires may not increase as much as in other places.

MATERIALS

- PowerPoint presentation
- Student handout [1 per student]
- Dataset [1 per student]
- An assortment of supplies to be used for creative projects such as:
  - Rulers
  - Colored pencils and/or markers
  - Poster board
  - Paper

PREPARATION

1. Set up a computer and projector and display the PowerPoint presentation.
2. Prepare creative project supplies for student use. If you have space, it is helpful to lay the supplies out on a surface so that students can more quickly access available supplies and develop project ideas. Supplies will not be used until day 2.

PROCEDURES

DAY 1: INTRODUCTION AND IDENTIFYING A DATA TREND

Introduction

1. **Slide 1**: Today, we are going to talk about the effects of climate change on wildfire in various ecosystems and start on a project to analyze data on wildfires.
2. **Slide 2**: On July 27, 2018, a pair of wildfires started in California. These wildfires (separately called the Ranch and River fires and collectively referred to as the Mendocino Complex Fire due to their close proximity) got very large very quickly, due to a combination of hot temperatures, low humidity, and strong winds. This made it hard for firefighters to contain, and by August 7, 2018, the fires had burned 443 square miles. That sounds large, but how big is that really?
3. **Slide 3**: This infographic shows us that on August 7th, the Mendocino Complex Fire was bigger than Paris and New York City.
4. **Slide 4**: The Mendocino Complex Fire was fully contained on September 19, 2018, meaning that it burned for 56 days total and devastated over 717 square miles. These photos were taken on August 3, 2018 from the International Space Station, which orbits at over 250 miles above the surface of the earth. Even if we don't live in California, large wildfires can affect us. Point out the smoke visible in the photo. Wildfires are a natural part of ecosystem health (and some vegetation types require fire for reproduction), but large wildfires can have negative effects on humans and the environment.
5. **Slide 5**: The goal of a data jam is to examine data and

communicate it in a unique way through a creative project. Today we will start by looking at a dataset about wildfire and identifying a data trend.

6. **Slide 6**: The US is divided into ecoregions. What does ecoregion mean? Eco – ecosystem, region – an area defined by similar characteristics. Ecoregions are areas defined by similar ecosystems.
7. **Slide 7**: The dataset we will be using focuses on these 5 ecoregions that make up the majority of land in the Western US.
   a. Northwestern great plains
   b. Western cordillera (cordillera means "mountain range" in Spanish, parallel mountain ranges and spaces in between, includes the Rocky Mountains, Cascades, Sierra Nevada mountains, and many smaller ranges)
   c. Cold desert (primarily represented by the Great Basin Desert in Nevada and Utah)
   d. Warm desert (Chihuahuan Desert in southern New Mexico and west Texas)
   e. South-central semi-arid prairie (What does arid mean? Dry. What is a prairie? Open grassland.)
8. **Slide 8**: Show students photos of each ecoregion. Ask students what ecoregion looks the coldest, warmest, wettest, or driest. Point out the differences in vegetation.
9. **Slide 9**: The main variable in our dataset is VLFs, or Very Large Fires.
10. **Slide 10**: The Mendocino Complex Fire is an example of a VLF. VLFs are wildfires burning over 5,000 hectares (12,355 acres, or 19.3 square miles). That is larger than 9,000 football fields (9343.67 football fields exactly). They account for only the top 5 – 10% of large wildfires, but they make up a majority of burned area. They are important to study because they have large impacts on humans and the ecosystem.
11. **Slide 11**: The frequency of large wildfires is changing across the globe. What is happening that could cause this? [Answer: climate change].
    a. This map shows changes to "fire weather season", which affects how often areas can expect conditions suitable for wildfires. Red indicates longer or more frequent long fire seasons, and blue indicates shorter or less frequent long fire seasons. The map uses data from 1979 – 2013, so this map indicates that the majority of the earth is experiencing some change in conditions that affect wildfire occurrence.
12. **Slide 12**: For this project, we will focus on the western US. This map shows historic (1971 – 2000) VLF potential for 5 regions that make up the majority of the western US. VLF potential is defined as the mean annual VLF's per 10,000 km^2 area. The height of the flame is scaled to represent the VLF potential of each region. Do all regions historically have the same VLF potential? [Answer: No, some are higher than others.]
13. **Slide 13**: This map shows the future (2041 – 2070) predicted VLF potential for the same regions. Will the VLF potential be higher or lower in the future? [Answer: All regions will see increases in VLF potential].
14. **Slide 14**: The second table in the dataset includes data on factors that may affect VLF potential. This includes average maximum temperature in each ecoregion.
15. **Slide 15**: This map shows that average maximum temperatures are increasing in most parts of the United States. Ask students how temperature increases due to climate change can affect VLF potential. Increasing temperatures lead to dry and flammable fuel. Drought also kills plants, which become fuel for fire.
16. **Slide 16**: Another variable we will be using in our data jam projects is "potential ET," or potential evapotranspiration. Evapotranspiration has to do with how much moisture is in an ecosystem.
17. **Slide 17**: Which of the locations shown in these photos would have a more severe wildfire? Students likely already have some prior knowledge about fire that will help them make an educated prediction. They can discuss with their neighbor, and then hold up either a one or two to vote. [Answer: Photo 1, because photo 2 is a rainforest and contains a lot of moisture, so it would be more difficult for a fire to ignite.]
18. **Slide 18**: Evapotranspiration is the process of water entering the atmosphere from evaporation and transpiration (from plants). Potential evapotranspiration takes into account temperature, wind speed, solar radiation, and relative humidity. What do hotter temperatures mean for evapotranspiration? [Answer: More evapotranspiration.] The dry forest in Photo 1 may be experiencing greater evapotranspiration than the rainforest in Photo 2.
19. **Slide 19**: Another variable that can affect large wildfire potential is above ground dead biomass.
20. **Slide 20**: Which location would have a more severe wildfire? Students can discuss with their neighbor, and then hold up one or two fingers to vote. [Answer: Photo number 2 would ignite and spread more easily, burning more severely because it has more dead, dry fuel which is flammable.]
21. **Slide 21**: Biomass means organic matter – dead leaves, stems, bark, branches, tree trunks etc. Carbon is stored in biomass, and this is represented in units of grams of carbon per meter squared. Photo 2 would have more above ground dead biomass than Photo 1.
22. **Slide 22**: We just reviewed variables in our dataset, or things scientists collected data on. You can find variables in the column titles on the data tables. Have students answer questions 1 and 2 on their handout.

Identifying a Data Trend

1. **Slide 23**: A data trend is a pattern in a dataset. You are going to look for a data trend that includes data about VLF potential from table 1. Question 3 on the handout includes four fill-in-the-blank sentences to help you find patterns in table 1. If needed, answer question 3a as a class [All ecoregions are expected to increase in VLF potential], then have students work with their groups to answer the rest of question 3.
2. **Slide 24**: Your data trend should also include at least one variable from table 2 of your dataset. Have students choose a sentence starter from question 3 to complete using data from table 2, and answer question 4 on their handout. There is not a "correct answer" – meaning that there's not just one factor that influences VLF potential.
   a. Example: All ecoregions are expected to __*increase*___ in VLF potential… and the temperature is expected to increase.
3. **Slide 25**: The data trend you choose for your project does not have to include all the information seen in the data tables. It should include variables from table 1 and table 2, it should be specific, and it should be concise. Students should combine their answers to questions 3 and 4 to write a one-sentence data trend to answer question 5. This is the data trend they will represent creatively in their data jam project.
   a. By the end of class, groups should have a data trend written down and be ready to start on their creative project next time.
   b. Example data trends from this dataset:
      i. All ecoregions are expected to increase in VLF potential, average maximum temperature, and potential evapotranspiration.
      ii. South central semi-arid prairies and warm deserts will experience the smallest absolute increase in VLF potential, and they are the ecoregions with the warmest future and historic temperatures.
      iii. In the future, cold deserts, western cordillera, and northwestern great plains will have the highest VLF potential, and they will have the highest percent change in potential ET.
      iv. Western Cordillera and cold deserts will have the greatest changes in above ground dead biomass, and they are the two ecoregions with the greatest future VLF potential.
      v. Cold deserts will see the greatest absolute increase in VLF potential, and they are also one of only two ecoregions expected to have an increase in above ground dead biomass.

*Note: If your students are familiar with Claim Evidence Reasoning writing, they can think of their data trend as a claim, the data is the evidence, and they are giving their reasoning in question 6.

DAY 2: CREATIVE PROJECT PREPARATION

1. **Slide 27**: Remind students that the goal of a data jam is to communicate wildfire data in a creative way. Last time, we identified the data trend you will use in your project. Today we will find a way to creatively represent that data trend.
2. **Slide 28**: A creative representation of data can make the information more accessible to someone that may not know much about the topic you are representing.
   a. This necklace, created by data artist Stefanie Posavec, represents a week of data on air quality (amount of particulates) in Sheffield, UK. The smooth pieces represent few particulates, and the large spiky pieces represent high levels of particulates. The large red spike represents the city's annual "bonfire night", which is celebrated with fireworks displays and large bonfires.
   b. You can see that it has a scale, where the darker red and larger spikes represent worse air quality.
3. **Slide 29**: A science journalist is responsible for understanding scientific information and communicating it to the general public. They might make an infographic that represents the data in a visually appealing and accurate way. If you make an infographic, you need to have a scale and key that explain how your visuals represent the data. A scale can be created by multiplying or dividing your data by the same numbers to scale your data up or down in a way that works for your project.
4. **Slide 30**: In this infographic we looked at earlier, the height of the flame is scaled to represent the VLF potential of each ecoregion. 1-inch height of the flame (measured with a ruler) is equal to 1 VLF per 10,000 km^2 per year. Scaling the data accurately allows us to represent numbers with images.
5. **Slide 31**: Some artists choose to represent environmental issues through poems, songs, or other artwork. If you would like to write a poem, song, or create other artwork to communicate your data trend, make sure to include specific references to the actual data like this poem does. This example of an acrostic poem was written about data on water use in different countries. Notice how specific data are incorporated for each country.
6. **Slide 32**: Instructions for the rest of class –
   a. Decide on what type of creative project you would like to make.
   b. Brainstorm your project, and use the rest of class to create it.

   c. If you finish early, start thinking about how you will present your project to the class next time.
7. Direct students to work in their groups to decide what creative project they would like to make, and answer questions in the Creative Project section on their worksheet. Use the rest of class to complete their creative projects.
8. If they finish early, they can start thinking about their presentation for next class.

DAY 3: PRESENTATIONS

1. Have students prepare a short (~2-3 minute) presentation of their data trend and creative project. They should tell everyone what their data trend was and explain the creative project they made.
2. After each group presents, lead a class discussion. Ask students if they noticed any common themes in the data trends presented by other groups. What are the characteristics of different ecoregions that could influence the VLF potential? Is climate change expected to have an impact on wildfire? Why?

ADDITIONAL RESOURCES

Barbero, R., Abatzoglu, J.T., Larkin, N.K., Kolden, C.A., Stocks, B. 2015. Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire 24(7).

CONUS Climate Console. Climate projections for the continental United States. Conservation Biology Institute. Web. <http://climateconsole.org/conus>

Environmental Protection Agency (EPA), Ecoregions. Modified 27 Mar 2018, Web. Accessed 26 Jun 2020. <https://www.epa.gov/eco-research/ecoregions>.

DATASET INFORMATION

Dataset Table 1

Historic VLF potential (1971 - 2000) was calculated using recorded historic fire occurrence data. Future VLF potential (2041 - 2070) was calculated by using a variety of predictors proven to be linked to fire occurrence in each ecoregion (temperature, precipitation, relative humidity, drought severity, and fire danger indices).

Dataset Table 2

Data from CONUS was divided ecoregions into smaller “sections”. Sections were chosen that represented the general characteristics of the larger ecoregion.

Western cordillera ecoregion -"beaverhead mountains" section
*Northwestern great plains - "northwestern great plains" section
South-central semiarid prairies - "pecos valley" section
Cold deserts - "bonneville basin" section
Warm deserts - "basin and range" section

*Barbero et al. (2015) refers to west-central semi-arid prairies, which is synonymous with northwestern great plains. The latter was chosen to simplify the dataset for student use.

Historic values were calculated from 1981 - 2000 based on measured climatological data. Future values were modeled for the years 2061 - 2070 using the Beijing Climate Center Climate System Model (BCC-CSM1.1), and are representative of an average of models.